TRIUMF Experiment E614
Technical Note #45

Measurement of Cital Spacer Thickness by Glass Ruler

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Glass rulers have manufactured using a special tool providing spacing of 1mm between adjacent grooves with a random error $\sigma = 2\mu$. An accumulated error was $\Delta_{acc.}$ $(\mu)= +/-2 + 3\cdot10^{-3}\cdot L$ (mm), where L is distance between two grooves. L_{max} = 330mm for our rulers. It corresponds to an accumulated error between $+3\mu$ and -1μ. Wavelength of an HeNe laser has been used as the spacing standard.

Thickness of 4, 20 and 40mm Cital spacers and glass rulers during manufacturing have measured using standard spacers with thickness of 4.0005mm and 20.0000mm. 1.997mm Cital spacers have manufactured using a standard 1.9995mm spacer. Spacer and glass ruler thickness have measured again using the above standard spacers [1].

The HeNe laser standard defines spacing between wires (unit $U_{U,V}$ for U and V axes of E614 detector). The 4 and 20mm standards define unit U_Z for Z axis of the detector. Identity I = $|U_{U,V}/U_Z|$ of the both units is important for a correct reconstruction of Michel spectrum. A crucial value of $|I-1|_c = 5\cdot10^{-4}$ causes a systematic shift of Michel parameters: $|P_\mu\xi-1| = 6\cdot10^{-5}$, $|\rho-0.75|$ $= 10^{-4}$, $|\delta-0.75| = 1.1\cdot10^{-4}$ [2]. Therefore an average thickness of 4, 20 and 40mm spacers, have defined originally in the U_Z units, have measured using one glass ruler ($U_{U,V}$ unit) mounted permanently on winding tool. The measuring scheme is shown in Fig.1. A microscope sees groove #1, its mirror reflection from polished surface of the spacer, and nearest groove #2. It provides measurement of 2Δ spacing relative to the spacing of 1mm between adjacent grooves. The spacing 2Δ has been measured at both sides of a spacer. Thickness of the spacer is $L_{U,V}$= $1\text{mm}\cdot N - \Delta_R - \Delta_L$. Where N is number of intervals between grooves covered by a spacer, Δ_R and Δ_L corresponds to right and left side of the spacer.

Average spacer thickness has been measured using a several spacer assembly covering total length about 280mm in order to improve accuracy. The assembly contains 70, 14 or 7 spacers with thickness of 4, 20 or 40mm correspondingly. Results are shown in Table.

Spacer assembly	$2\Delta_R$ (μ)	$2\Delta_L$ (μ)	Thickness (U_Z, mm)	Thickness ($U_{U,V}$, mm)	$\|I-1\|$/Error (10^{-5})
"4mm"×70	56	44	279.935	279.950	5.4/7.1
"20mm"×14	83	105	279.905	279.906	0.4/7.1
"40mm"×7	69	107	279.900	279.912	4.3/7.1

Visible images are shown in Figs.2, 3. A ruler with 0.1mm scale is placed on the glass ruler surface to do an independent measurement of 2Δ value. Typical results of several 2Δ

measurements using 1mm and 0.1mm ruler are shown in Table. Value of 20μ is accepted as a measuring error. It corresponds to visible image width of a diamond made groove. Some systematic errors can appear because both the spacer surface and the microscope optical axis are not exact orthogonal to the glass ruler surface. One can estimate that possible angle deviations < 5° can give a systematic error < 2μ. Pressing force on spacer assembly was about 100kg. It corresponds to the assembly shortening about 4μ.

We can estimate the measured identity from the Table. A pessimistic estimation is $|I-1|_m \le 1.25 \cdot 10^{-4}$ ($5.4 \cdot 10^{-5}$ is maximum nonidentity + $7.1 \cdot 10^{-5}$ is the error). The measured value $|I-1| = 1.25 \cdot 10^{-4}$ is 4 time less than the crucial one ($|I-1|_c = 5 \cdot 10^{-4}$). It means we have a base to manufacture the E614 detector with a surplus accuracy. Identity of the above units to a world standard length unit can be checked by a measurement of the maximum momentum p_e = 52.8273MeV/c for $\mu \to e$ decay at a known magnetic field B. An independent measurement of our units by a world standard unit will be useful also.

Reference

1. V.I. Selivanov, TN-18, 23 July 1998
2. Review of the Experiment 614 TRIUMF, December 1993

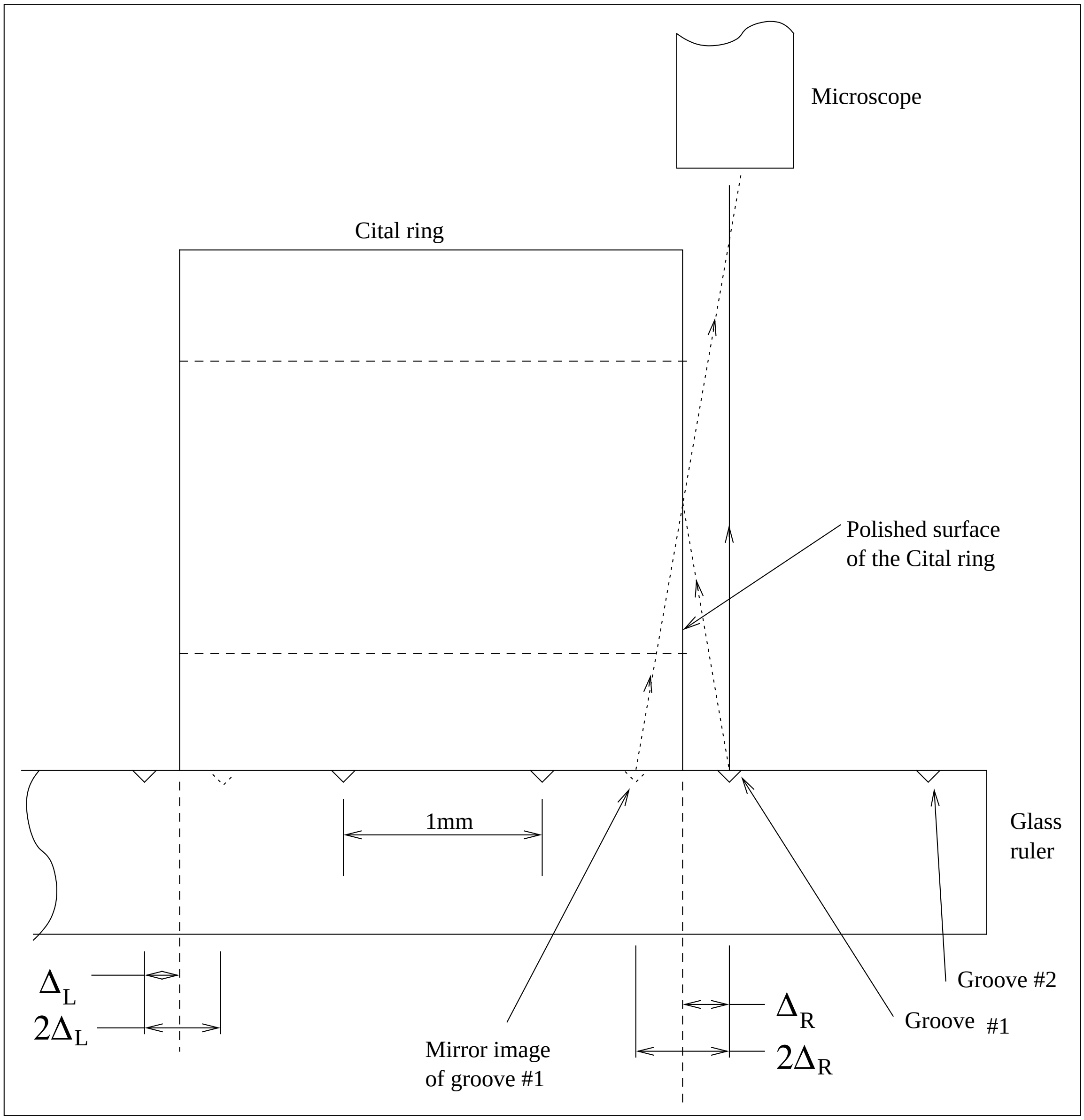

Fig.1. Tool for Cital ring thickness measurement by a glass ruler.

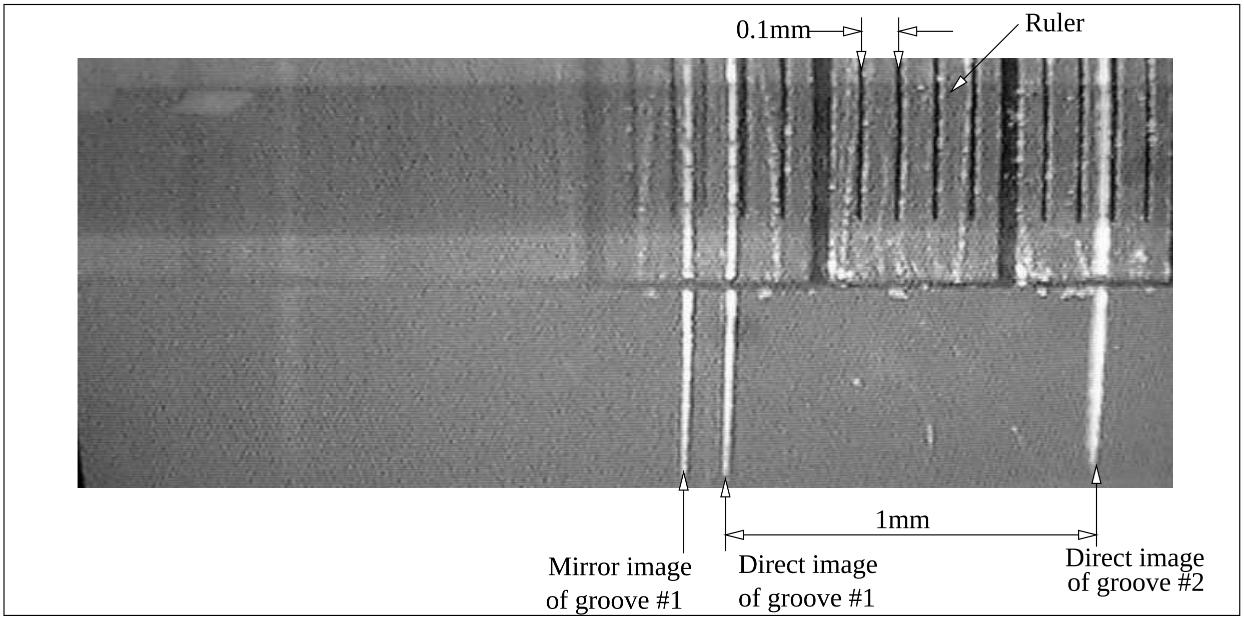

Fig.2. Visible images near right side of "40mm x 7" assembly

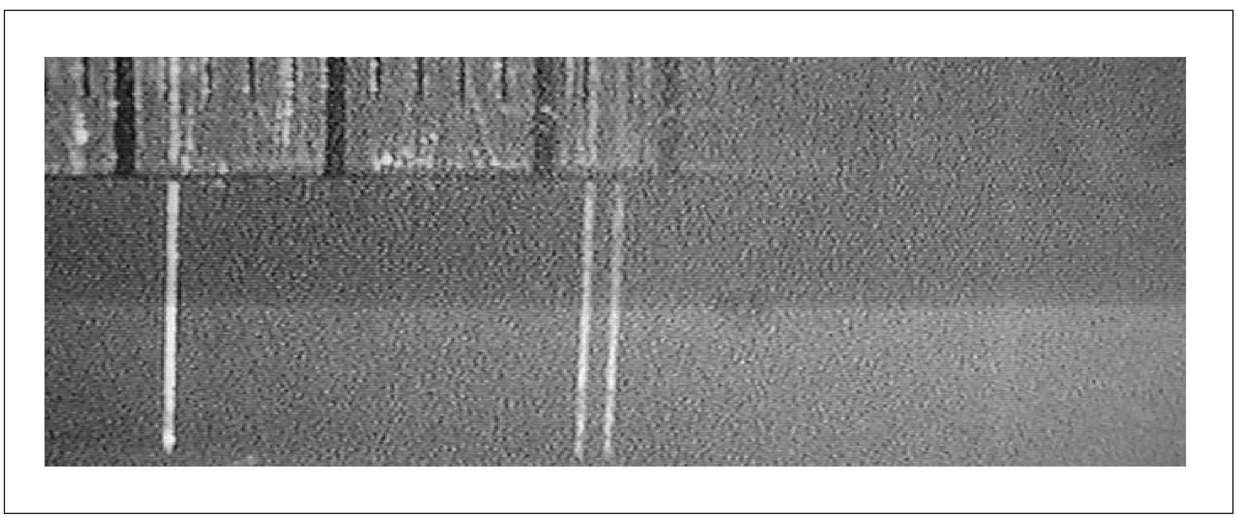

Fig.3. Visible images near left side of "40mm x 7" assembly